



**Item 9.2: Real-Time Market Price Correction  
for Operating Days October 16-20, 23-24, 26  
& 29-31, 2019 and November 4 & 6, 2019**

*David Maggio*

Sr. Manager, Market Analysis & Validation

Board of Directors Meeting

ERCOT Public

December 10, 2019

# Issue for Board Consideration

- On Operating Days (ODs) October 16-20, 23-24, 26 & 29-31, 2019 and November 4 & 6, 2019, prices in the Real-Time Market (RTM) were impacted by two separate but related software errors. Because the deadline for ERCOT to correct prices for these ODs has passed, ERCOT is seeking Board determination as to whether prices have been “significantly affected by an error,” and if so, authorization from the Board for ERCOT staff to correct prices for some/all of the affected ODs.
- ERCOT recommends that the Board:
  - a) Make a determination that Real-Time prices for certain intervals on ODs October 16-20, 23-24, 26 & 29-31, 2019 and November 4 & 6, 2019, were significantly affected by software errors; and
  - b) Direct/authorize ERCOT staff to correct some or all such prices for those ODs.



# Background

- **October 16, 2019** – A system enhancement was deployed for the calculation of Electrical Bus Shift Factors in the RTM.
  - Enhancement intended to align the calculation of Electrical Bus Shift Factors for the Electrical Bus connecting a Generation Resource when that Electrical Bus is energized in the base case but disconnected by a contingency.
  - Prior to the change, the Shift Factor of an Electrical Bus connecting a Generation Resource was assigned a non-zero “pickup” Shift Factor if the Generation Resource was energized in the base case, but disconnected by a contingency. This did not align with other Electrical Buses by the same contingency.
  - Software Implementation Error – The system inadvertently set all Shift Factors associated with that Electrical Bus to “0” if any active contingency disconnected an Electrical Bus. As a result, the Shift Factors for some Electrical Buses were incorrectly set to “0” and used in downstream applications.
- **October 21, 2019** – ERCOT became aware of the software error, began investigating RTM prices, and implemented an emergency patch.
- **October 23, 2019** – ERCOT issued RTM price correction for OD October 21, 2019.
- **October 24, 2019** – ERCOT issued [Market Notice M-A102419-01](#).

# Background

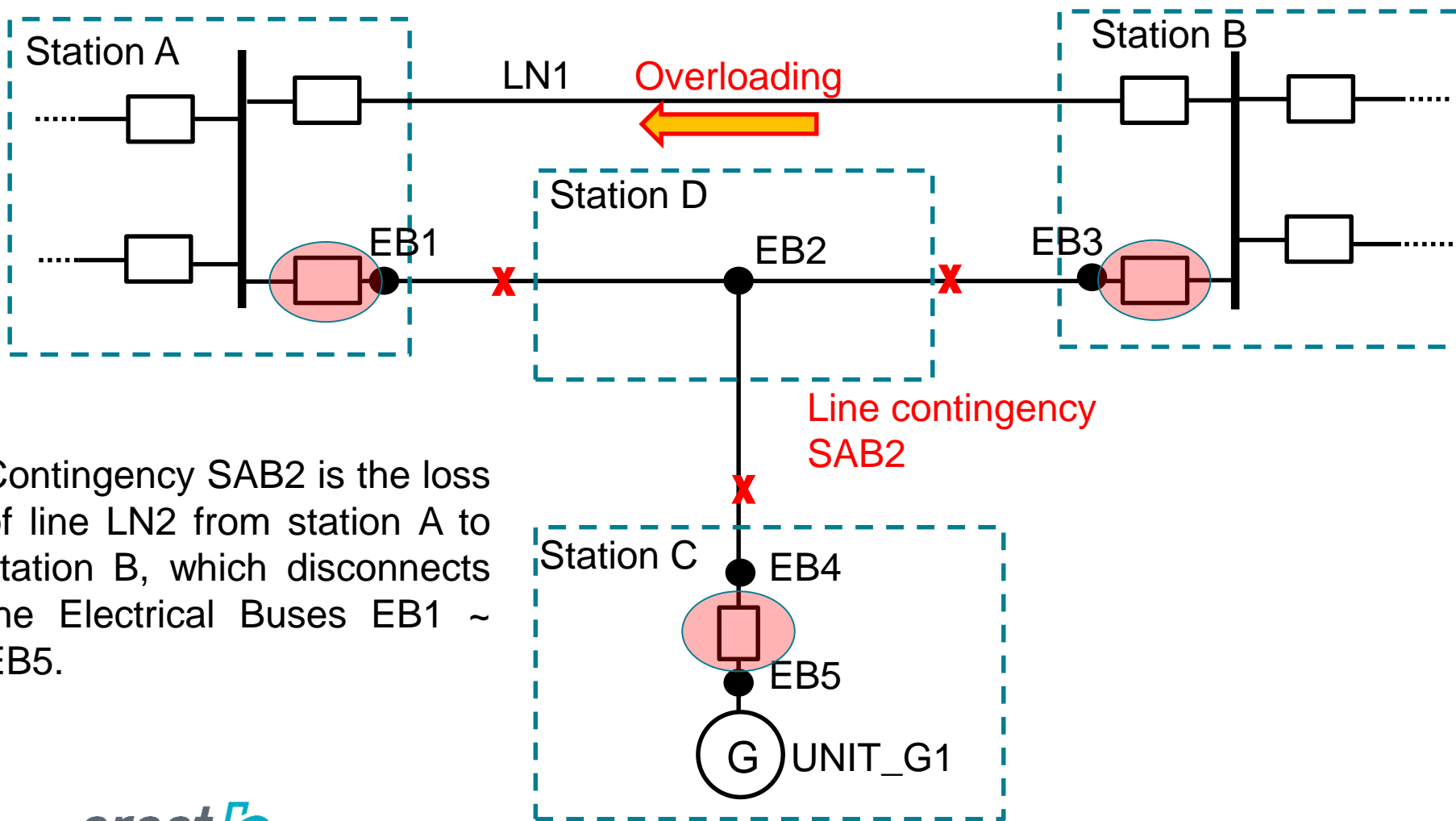
- **November 6, 2019** – During review of the RTM Electrical Bus Shift Factor issue, a separate but related software error was identified.
  - The software intended to capture the list of Electrical Buses that are fully disconnected from the rest of the ERCOT grid under a contingency, also incorrectly included Electrical Buses that are on the end of open-ended transmission equipment under contingency.
- **November 7, 2019** – ERCOT began further investigating RTM prices and implemented an emergency patch.
- **November 14, 2019** – ERCOT issued [Market Notice M-A102419-02](#).

## Impacted ODs

- ODs 10/16/2019 – 10/21/2019: Impacted by both software errors
  - Note – 10/21/2019 prices were corrected prior to becoming final
- ODs 10/23/2019 – 10/24/2019, 10/26/2019, 10/29/2019 – 10/31/2019, 11/04/2019, and 11/06/2019
  - Note - Only impacted by the error identified on 11/06/2019



# Background – Constraint with Disconnected Electrical Buses



Contingency SAB2 is the loss of line LN2 from station A to station B, which disconnects the Electrical Buses EB1 ~ EB5.

# Background – Electrical Bus Shift Factor

For each Security-Constrained Economic Dispatch (SCED) interval, each Electrical Bus Shift Factor is calculated per constraint and per Electrical Bus where a constraint is defined as a pair of a contingency and a piece overloaded equipment.

Example of system prior to the enhancement on October 16, 2019:

Assuming two constraint in SCED, constraint SAB2:LN1 disconnects the Electrical Buses EB1~EB5, while the other constraint SCD1:LN8 does not disconnect any of the same Electrical Bus.

SCED Interval	Contingency	Overload	Electrical Bus/ Resource	Shift Factor
...				
10/1/2019 10:35	SAB2	LN1	EB1	0
10/1/2019 10:35	SAB2	LN1	EB2	0
10/1/2019 10:35	SAB2	LN1	EB3	0
10/1/2019 10:35	SAB2	LN1	EB4	0
10/1/2019 10:35	SAB2	LN1	EB5	-0.02
10/1/2019 10:35	SAB2	LN1	UNIT_G1	-0.02
...				
10/1/2019 10:35	SCD1	LN8	EB1	0.05
10/1/2019 10:35	SCD1	LN8	EB2	0.05
10/1/2019 10:35	SCD1	LN8	EB3	0.05
10/1/2019 10:35	SCD1	LN8	EB4	0.05
10/1/2019 10:35	SCD1	LN8	EB5	0.05
10/1/2019 10:35	SCD1	LN8	UNIT_G1	0.05
...				

Should be set to "0" to align with other disconnected Electrical Buses

# Background – Initial Software Error

The intended enhancement was designed to reset Electrical Bus Shift Factors for only the disconnected Electrical Buses, and for only the constraint where its contingency disconnected the Electrical Buses.

However, the change was incorrectly applied to all Electrical Bus Shift Factors, including Shift Factors for other unrelated constraints.

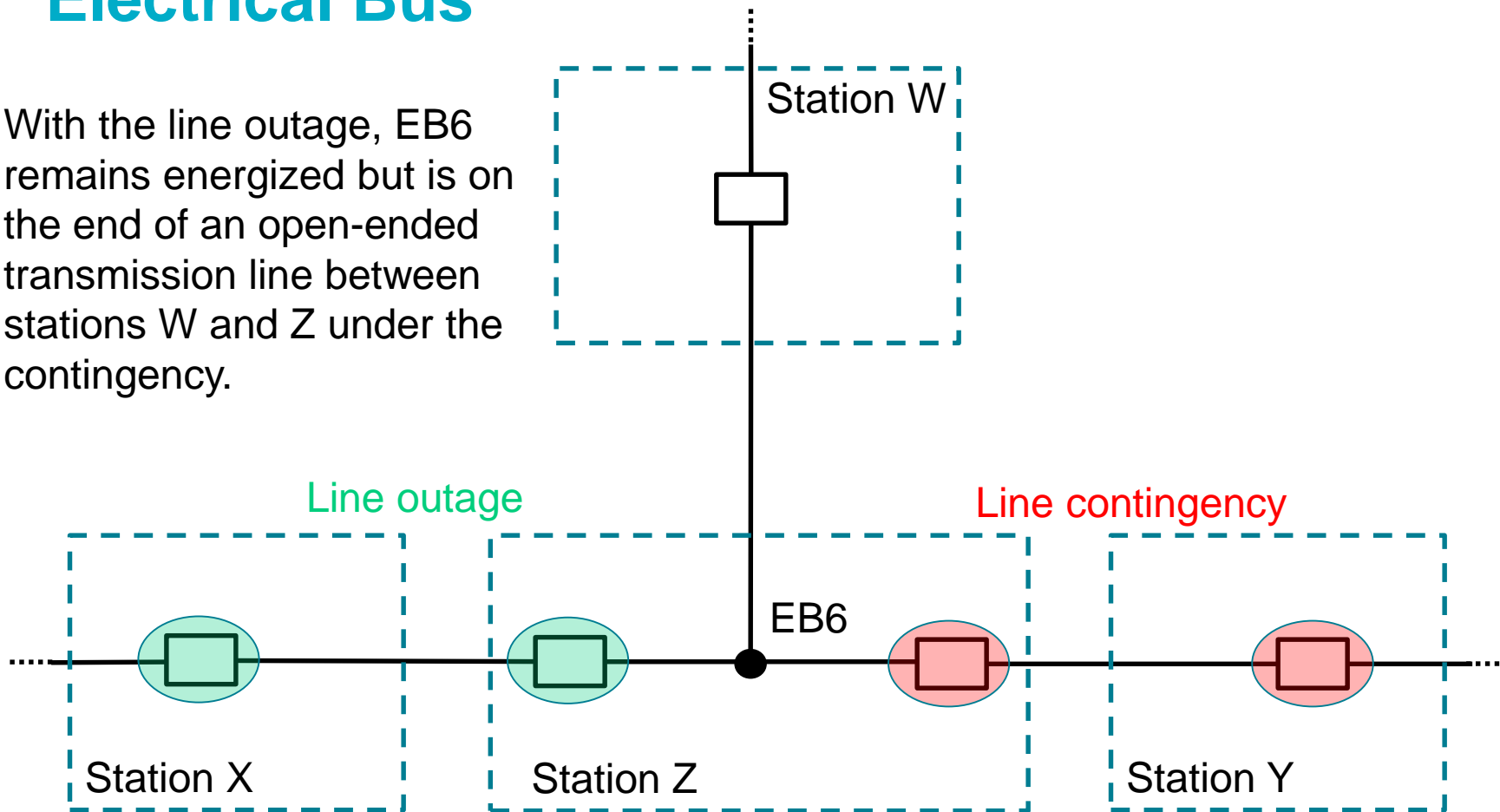
Example of system after the enhancement on October 16, 2019

SCED Interval	Contingency	Overload	Electrical Bus/ Resource	Shift Factor
...				
10/1/2019 10:35	SAB2	LN1	EB1	0
10/1/2019 10:35	SAB2	LN1	EB2	0
10/1/2019 10:35	SAB2	LN1	EB3	0
10/1/2019 10:35	SAB2	LN1	EB4	0
10/1/2019 10:35	SAB2	LN1	EB5	0
10/1/2019 10:35	SAB2	LN1	UNIT_G1	-0.02
...				
10/1/2019 10:35	SCD1	LN8	EB1	0
10/1/2019 10:35	SCD1	LN8	EB2	0
10/1/2019 10:35	SCD1	LN8	EB3	0
10/1/2019 10:35	SCD1	LN8	EB4	0
10/1/2019 10:35	SCD1	LN8	EB5	0
10/1/2019 10:35	SCD1	LN8	UNIT_G1	0.05
...				

The disconnected Electrical Buses Shift Factors for other unrelated constraints were also incorrectly set to "0"

# Background – Constraint with an Open-Ended Electrical Bus

With the line outage, EB6 remains energized but is on the end of an open-ended transmission line between stations W and Z under the contingency.





# Price Correction Study

- Market: RTM
- Impacted ODs:
  - October 16-20, 23-24, 26 & 29-31, 2019
  - November 4 & 6, 2019
- Price Correction Methodology:
  - ERCOT reran the SCED pricing calculations to determine Real-Time Locational Marginal Prices (RTLMPs) with corrected Electrical Bus Shift Factors, and then recalculated Real-Time Settlement Point Prices (RTSPPs) and EPS Meter Prices (RTRMPRs) for intervals affected by the software error.
- The following slides include analysis of the Settlement impacts of changing the prices.

# Price Correction and Settlement Impact Review

- The software errors only affected pricing calculations and did not affect the Resource Base Points in the RTM. Therefore, ERCOT's analysis used original MW quantities with corrected prices based on corrected Electrical Bus Shift Factors.
  - Note: The Settlement data provided herein is an estimate; final Settlement amounts may differ.
- All Settlement amounts are net amounts due to/from ERCOT in \$. Negative amounts are increased payments to Market Participants; positive amounts are increased charges.
- The % amount is the absolute value of the % of impact to the previously settled net amount due to/from ERCOT.

# Settlement Impacts – ODs Affected by Both Errors

	10/16		10/17		10/18	
Energy Imbalance	\$60k	1.3%	\$5k	0.4%	\$123k	2.3%
PTP Obligations	(\$54k)	1.0%	(\$8k)	0.6%	(\$91k)	1.8%
RENA	(\$6k)	0.7%	\$3k	24.7%	(\$32k)	18.9%

	10/19		10/20	
Energy Imbalance	\$286k	2.5%	\$95k	2.1%
PTP Obligations	(\$185k)	1.8%	(\$39k)	0.8%
RENA	(\$101k)	7.8%	(\$56k)	12.6%

# Settlement Impacts – ODs Only Affected by Error Identified on November 6, 2019

	10/23		10/24		10/26	
Energy Imbalance	(\$24)	-	-	-	(\$116)	-
PTP Obligations	\$30	-	-	-	\$32	-
RENA	(\$7)	-	-	-	\$85	0.2%

	10/29		10/30		10/31	
Energy Imbalance	(\$34)	-	(\$75)	-	(\$83)	-
PTP Obligations	\$29	-	\$61	-	\$145	-
RENA	\$5	-	\$14	-	(\$64)	-

	11/4		11/6	
Energy Imbalance	-	-	(\$4)	-
PTP Obligations	-	-	\$8	-
RENA	-	-	(\$4)	-





**Date:** December 3, 2019  
**To:** Board of Directors  
**From:** Kenan Ögelman  
**Subject:** Real-Time Market Price Correction for Operating Days  
October 16-20, 23-24, 26 & 29-31, 2019 and November 4 & 6, 2019

**Issue for the ERCOT Board of Directors**

**ERCOT Board of Directors Meeting Date:** December 10, 2019

**Item No.:** 9.2

**Issue:**

Pursuant to paragraph 6 of Protocol Section 6.3, Adjustment Period and Real-Time Operations Timeline, whether the ERCOT Board of Directors (Board) should approve price corrections for Real-Time Locational Marginal Prices (RTLMPs), Real-Time Settlement Point Prices (RTSPPs), Real-Time Settlement Point Prices Energy-Weighted (RTSPPEWs) and EPS Meter Prices (RTRMPRs) for certain intervals on Operating Days October 16-20, 23-24, 26, 29-31, 2019 and November 4 & 6, 2019, that were affected by software errors.

**Background/History:**

ERCOT staff has identified the need to correct prices in the Real-Time market (RTM) for certain Security-Constrained Economic Dispatch (SCED) intervals and Settlement Intervals on Operating Days October 16-20, 23-24, 26 & 29-31, 2019 and November 4 & 6, 2019. The impacted prices include:

- RTLMPs;
- RTSPPs;
- RTSPPEWs; and
- RTRMPRs.

The ERCOT Protocols require ERCOT to correct prices when invalid prices are identified in an otherwise valid market solution. If ERCOT determines that prices are erroneous, ERCOT must correct the prices before they are final. Prices are final at 1600 on the second Business Day following the Operating Day. However, if ERCOT determines that prices are erroneous and need correction after they are final, then ERCOT can seek Board review of such prices if, within 30 days of the Operating Day, ERCOT notifies Market Participants of the need for correction and that ERCOT intends to seek Board approval of the correction.

The Board may review and change prices if the Board finds that such prices are “significantly affected by an error,” and ERCOT gave timely notice to Market Participants. The Board may rely on the following reasons to find that prices were significantly affected by an error:

- **Data Input Error:** Missing, incomplete, stale, or incorrect versions of one or

more data elements input to the market applications may result in an invalid market solution and/or prices.

- Data Output Error: These include: (i) incorrect or incomplete data transfer, (ii) price recalculation error in post-processing, and (iii) Base Points inconsistent with prices due to the Emergency Base Point flag remaining activated even when the SCED solution is valid.
- Hardware/Software Error: These include unpredicted hardware or software failures, planned market system or database outages, planned application or database upgrades, software implementation errors, and failure of the market run to complete.
- Inconsistency with the Protocols or Public Utility Commission of Texas (PUCT) Substantive Rules: Pricing errors may occur when specific circumstances result in prices that are in conflict with such Protocol language or the PUCT Substantive Rules.

(See ERCOT Protocol Sections 6.3(4)-(6).)

On October 21, 2019, ERCOT became aware of a software error that occurred during an update to ERCOT's Energy and Market Management System (EMMS). On October 16, 2019, ERCOT deployed a system enhancement for the calculation of Electrical Bus Shift Factors for active constraints in the RTM. This system enhancement was intended to set the Shift Factor of an Electrical Bus for a single constraint to "0" if the contingency related to the constraint disconnects the Electrical Bus. However, following the system enhancement, where an active contingency disconnected an Electrical Bus, all Shift Factors associated with that Electrical Bus were incorrectly set to "0." As a result, the Shift Factors for some Electrical Buses were incorrectly set to "0" and used in the calculations for certain RTLMPs, RTSPPs, RTRMPRs, and RTSPPEWs. Because SCED uses Resource Shift Factors rather than Electrical Bus Shift Factors in its dispatch optimization, Resource Base Points were unaffected by this error. Upon identification of the software error, ERCOT immediately implemented an emergency fix and began investigating RTM prices for Operating Days October 16-21, 2019. ERCOT determined that the software error resulted in incorrect Real-Time prices for certain Settlement Intervals on Operating Days October 16-21, 2019.

On October 24, 2019, ERCOT notified Market Participants of the software error, and described the need for correction. ERCOT further informed Market Participants that it corrected prices for Operating Day October 21, 2019, before prices became final. ERCOT advised would be seeking Board review of RTM prices for Operating Days October 16-20, 2019. (See Market Notice M-A102419-01.)

Upon further review of the software error, ERCOT identified a separate but related software error. ERCOT determined that for Operating Days October 16, 2019-

November 7, 2019, the software intended to capture the list of Electrical Buses that are fully disconnected from the rest of the ERCOT grid under a contingency also incorrectly included Electrical Buses that are on the end of open-ended transmission equipment under contingency. ERCOT implemented an emergency fix and began investigating additional pricing impacts.

On November 14, 2019, ERCOT issued a second notice to Market Participants informing them of the separate but related software error. ERCOT informed Market Participants that there were no pricing impacts for the Operating Days affected by the original software error (i.e., Operating Days October 16-21, 2019). ERCOT further noted that there were no pricing impacts for Operating Days October 22, 25, 27-28, 2019, November 1-3, 5 or 7, 2019, as a result of the separate but related software error. However, for Operating Days October 23-24, 26 & 29-31, 2019 and November 4 & 6, 2019, ERCOT determined that the second software error impacted prices, and therefore ERCOT stated that it would be recommending these additional Operating Days to the Board for review of prices. (See Market Notice M-A102419-01.)

Accordingly, ERCOT requests that the Board:

- (a) Review RTLMPs, RTSPPs, RTRMPRs, and RTSPPEWs for Operating Days October 23-24, 26 & 29-31, 2019 and November 4 & 6, 2019;
- (b) Make a determination as to whether such prices were significantly affected by a software error; and
- (c) Direct/authorize ERCOT to correct some or all RTLMPs, RTSPPs, RTRMPRs, and RTSPPEWs for Operating Days October 23-24, 26 & 29-31, 2019 and November 4 & 6, 2019.

Attached hereto are documents containing the corrected prices for the RTLMPs, RTSPPs, RTRMPRs, and RTSPPEWs for Operating Days October 23-24, 26 & 29-31, 2019 and November 4 & 6, 2019, as follows:

- **Attachment A** – Price Correction RTLMPs (Electrical Buses);
- **Attachment B** – Price Correction RTLMPs (Settlement Points);
- **Attachment C** – Price Correction RTSPPs and RTSPPEWs; and
- **Attachment D** – Price Correction RTRMPRs.

### **Relevant Protocol Sections:**

#### **6.3 Adjustment Period and Real-Time Operations Timeline**

- (4) ERCOT shall correct prices when: (i) a market solution is determined to be invalid, (ii) invalid prices are identified in an otherwise valid market solution, (iii) the Base Points received by Market Participants are inconsistent with the Base Points of a valid market solution, unless accurate prices cannot be determined, or (iv) the Security-Constrained Economic Dispatch (SCED) process

experiences a failure as described in Section 6.5.9.2, Failure of the SCED Process. The following are some reasons that may cause these conditions.

- (a) Data Input error: Missing, incomplete, stale, or incorrect versions of one or more data elements input to the market applications may result in an invalid market solution and/or prices.
  - (b) Data Output error: These include: (i) incorrect or incomplete data transfer, (ii) price recalculation error in post-processing, and (iii) Base Points inconsistent with prices due to the Emergency Base Point flag remaining activated even when the SCED solution is valid.
  - (c) Hardware/Software error: These include unpredicted hardware or software failures, planned market system or database outages, planned application or database upgrades, software implementation errors, and failure of the market run to complete.
  - (d) Inconsistency with the Protocols or Public Utility Commission of Texas (PUCT) Substantive Rules: Pricing errors may occur when specific circumstances result in prices that are in conflict with such Protocol language or the PUCT Substantive Rules.
- (5) If it is determined that any Real-Time Settlement Point Prices, Settlement Point LMPs, Electrical Bus LMPs, Real-Time prices for energy metered, Real-Time On-Line Reliability Deployment Price Adders, Real-Time On-Line Reliability Deployment Prices, Real-Time On-Line Reserve Price Adders, Real-Time Off-Line Reserve Price Adders, Real-Time Reserve Prices for On-Line Reserves, Real-Time Reserve Prices for Off-Line Reserves, and/or constraint Shadow Prices are erroneous, ERCOT shall correct the prices before the prices are considered final in paragraph (6) below. Specifically:
- (a) If it is determined that correcting the Real-Time Settlement Point Prices will not affect the Base Points that were received by Qualified Scheduling Entities (QSEs), then ERCOT shall correct the prices before the prices are considered final in paragraph (6) below.
  - (b) If it is determined that correcting the Real-Time Settlement Point Prices will affect the Base Points that were received by QSEs, then ERCOT shall correct the prices before the prices are considered final and settle the SCED executions as failed in accordance with Section 6.5.9.2.
  - (c) If the Base Points received by QSEs are inconsistent with the Real-Time Settlement Point Prices reduced by the sum of the Real-Time On-Line Reliability Deployment Prices and the Real-Time Reserve Prices for On-Line Reserves averaged over the 15-minute Settlement Interval, then ERCOT shall consider those Base Points as due to manual override from



the ERCOT Operator and settle the relevant Settlement Interval(s) in accordance with Section 6.6.9, Emergency Operations Settlement.

- (6) All Real-Time LMPs, Real-Time Settlement Point Prices, Real-Time prices for energy metered, Real-Time On-Line Reliability Deployment Price Adders, Real-Time On-Line Reliability Deployment Prices, Real-Time Reserve Prices for On-Line Reserves, Real-Time Reserve Prices for Off-Line Reserves, Real-Time On-Line Reserve Price Adders, Real-Time Off-Line Reserve Price Adders and SASM MCPCs are final at 1600 of the second Business Day after the Operating Day.
- (a) However, after Real-Time LMPs, Real Time Settlement Point Prices, Real-Time prices for energy metered, Real-Time On-Line Reliability Deployment Price Adders, Real-Time On-Line Reliability Deployment Prices, Real-Time Reserve Prices for On-Line Reserves, Real-Time Reserve Prices for Off-Line Reserves, Real-Time On-Line Reserve Price Adders, Real-Time Off-Line Reserve Price Adders and SASM MCPCs are final, if ERCOT determines that prices are in need of correction and seeks ERCOT Board review of such prices, it shall notify Market Participants and describe the need for such correction as soon as practicable but no later than 30 days after the Operating Day. Failure to notify Market Participants within this timeline precludes the ERCOT Board from reviewing such prices. However, nothing in this section shall be understood to limit or otherwise inhibit any of the following:
- (i) ERCOT's duty to inform the PUCT of potential or actual violations of the ERCOT Protocols or PUCT Rules and its right to request that the PUCT authorize correction of any prices that may have been affected by such potential or actual violations;
  - (ii) The PUCT's authority to order price corrections when permitted to do so under other law; or
  - (iii) ERCOT's authority to grant relief to a Market Participant pursuant to the timelines specified in Section 20, Alternative Dispute Resolution Procedure.
- (b) The ERCOT Board may review and change Real-Time LMPs, Real-Time Settlement Point Prices, Real-Time prices for energy metered, Real-Time On-Line Reliability Deployment Price Adders, Real-Time On-Line Reliability Deployment Prices, Real-Time Reserve Prices for On-Line Reserves, Real-Time Reserve Prices for Off-Line Reserves, Real-Time On-Line Reserve Price Adders, Real-Time Off-Line Reserve Price Adders and SASM MCPCs if ERCOT gave timely notice to Market Participants and the ERCOT Board finds that such prices are significantly affected by an error.

- (c) In review of Real-Time LMPs, Real Time Settlement Point Prices, Real-Time prices for energy metered, Real-Time On-Line Reliability Deployment Price Adders, Real-Time On-Line Reliability Deployment Prices, Real-Time Reserve Prices for On-Line Reserves, Real-Time Reserve Prices for Off-Line Reserves, Real-Time On-Line Reserve Price Adders, Real-Time Off-Line Reserve Price Adders and SASM MCPCs, the ERCOT Board may rely on the same reasons identified in paragraph (4) above to find that the prices are significantly affected by an error.

**Key Factors Influencing Issue:**

Due to a software error, RTLMPs, RTSPPs, RTSPPEWs and RTRMPRs for certain intervals on Operating Days October 16-20, 23-24, 26 & 29-31, 2019 and November 4 & 6, 2019, were incorrect and cannot be corrected by ERCOT without authorization from the Board.

Analysis indicates that Real-Time market Energy Imbalance Settlement for a given affected Operating Day was impacted by as much as \$286K, depending on the Operating Day. Similarly, Real-Time market Settlement of Day-Ahead Market (DAM) Point-to-Point (PTP) Obligation was impacted by as much as \$185K, depending on the Operating Day.

**Conclusion/Recommendation:**

ERCOT recommends that the Board make a determination that some or all RTLMPs, RTSPPs, RTSPPEWs and RTRMPRs for certain intervals on Operating Days October 16-20, 23-24, 26 & 29-31, 2019 and November 4 & 6, 2019, were significantly affected by software errors, and authorize ERCOT to correct some or all RTLMPs, RTSPPs, RTSPPEWs and RTRMPRs for those Operating Days.



**ELECTRIC RELIABILITY COUNCIL OF TEXAS, INC.**  
**BOARD OF DIRECTORS RESOLUTION**

WHEREAS, paragraph (6) of Protocol Section 6.3 (October 1, 2019 Version), Adjustment Period and Real-Time Operations Timeline, authorizes the Board of Directors (Board) of Electric Reliability Council of Texas, Inc. (ERCOT) to approve price corrections only upon a finding that Real-Time Locational Marginal Prices (LMPs), Real-Time Settlement Point Prices, Real-Time prices for energy metered, Real-Time On-Line Reliability Deployment Price Adders, Real-Time On-Line Reliability Deployment Prices, Real-Time Reserve Prices for On-Line Reserves, Real-Time Reserve Prices for Off-Line Reserves, Real-Time On-Line Reserve Price Adders, Real-Time Off-Line Reserve Price Adders and Supplemental Ancillary Services Market (SASM) Market Clearing Prices for Capacity (MCPCs) have been significantly affected by an error; and

WHEREAS, pursuant to paragraph (6)(a) of Protocol Section 6.3, ERCOT gave timely notice to Market Participants that Real-Time Market prices for Operating Days October 16-20, 23-24, 26 & 29-31, 2019 and November 4 & 6, 2019, were incorrect and ERCOT would be seeking Board review of such prices; and

WHEREAS, after due consideration of the alternatives, the Board deems it desirable and in the best interest of ERCOT to correct some or all Real-Time Locational Marginal Prices (RTLMPs), Real-Time Settlement Point Prices (RTSPPs), Real-Time Settlement Point Prices Energy-Weighted (RTSPPEWs) and EPS Meter Prices (RTRMPRs) for certain intervals on Operating Days October 16-20, 23-24, 26 & 29-31, 2019 and November 4 & 6, 2019, that were significantly affected by software errors;

THEREFORE, BE IT RESOLVED, that the Board hereby (1) determines that certain RTLMPs, RTSPPs, RTSPPEWs and RTRMPRs for Operating Days October 16-20, 23-24, 26 & 29-31, 2019 and November 4 & 6, 2019 were significantly affected by software errors, and (2) authorizes ERCOT staff to implement the appropriate price corrections pursuant to paragraph (6) of Protocol Section 6.3.

**CORPORATE SECRETARY'S CERTIFICATE**

I, Vickie G. Leady, Assistant Corporate Secretary of ERCOT, do hereby certify that, at its December 10, 2019 meeting, the ERCOT Board passed a motion approving the above Resolution by \_\_\_\_\_.

IN WITNESS WHEREOF, I have hereunto set my hand this \_\_\_\_ day of December, 2019.

\_\_\_\_\_  
Vickie G. Leady  
Assistant Corporate Secretary